The Role of Egg Parasitoids to Control Rice Stem Borers (*Scirpophaga incertulas*) Walker (Lepidoptera: Pyralidae) in Subak Renon, Denpasar-Bali, Indonesia

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Abstract: The rice stem borers are the primary and endemic pests harming the rice plants. The intensity of the attacks varied reaching up to 90%, resulting in significant loss. It is essential to give careful consideration regarding this matter. An approach to address this issue is the adoption of integrated pest management (IPM) by using natural enemies for biological control. This research aims to investigate the role of egg parasitoids in the biological control of rice yellow stem borers. It was conducted at Subak Renon, located in Renon village, South Denpasar district, Denpasar regency, from April to July 2022. The research employed a random survey on truncate leaf rice containing eggs of rice stem borers. A weekly sampling had been performed on two-week-old Ciherang rice plants. The egg parasitoids were identified using the Kalshoven's identification key under a microscope while the proportion of egg parasitoids was calculated using the Nishida and Torri's formula. The findings revealed the presence of three species of egg parasitoids, *viz. Trichogramma japonicum* Ashm., *Telenomus rowani* Gahan, and *Tetrastichus schoenobii* Ferr. These parasitoids effectively suppressed the development of yellow rice stem borers, exhibiting a parasitization rate of 66%. *T. japonicum* had the highest parasitization rate, followed by *T. rowani*, and *T. schoenobii* Ferr.

Keywords: Biological control, egg parasitoids, parasitization rate, natural competitors

1. Introduction

The rice stem borer is a significant pest harming rice crops. The intensity of the attacks can reach up to 90%, resulting in losses of 125,000 tons per cropping season (Soejitno, 1984). From 2001 to 2014, the sizes of the affected areas were 1,105, 1672.2, 1689.5, 1,872, 1724.5, 2673.5, 1265.15, 823.55, 1223.25, 763.55, 639.4, 904.15, and 612.40 ha. The attack varied in intensity from mild to severe (BPTPH Bali, 2014).

Currently, farmers continue to depend on insecticides for effective time and energy management in their control operations. However, improper handling can lead to the development of pest resistance, the elimination of natural enemies, an increase in pest populations, and environmental degradation (Kartohardjono, 2011; Makarim *et al*., 2003). Another viable option for addressing the pest issues is to implement the principles of integrated pest management (IPM), incorporating the use of integrated and environmentally sustainable methods to control pests. The primary components of biological control are the use of natural enemies, such as parasitoids, predators, and pathogens, already available in nature.

One of the natural enemies used in biological control are egg parasitoids. It has the highest potential for development due to its ability to significantly minimize pest damage by targeting and killing bugs in their egg stage, as opposed to mortality occurring in the larval stages and pupae. Parasitoid eggs were deliberately engineered to be easily cultured in a substitute for the host eggs. These eggs have the characteristics of being relatively immobile compared to the larvae so as to facilitate and provide greater opportunities for the parasitism parasitoids (Widyarti, 2003).

Egg parasitoids are highly effective in controlling pests prior to causing damage to crops. The egg parasitoids of the rice stem borer are *Trichogramma japonicum* Ashmead (Hymenoptera: Trichogrammatidae), *Telenomus rowani* (Gahan) (Hymenoptera: Scelionidae), and *Tetrastichus schoenobii* Ferriere (Hymenoptera: Eulopidae) (Soejitno, 1991; Rauf 2000). The prevalence of parasitism in the third species is estimated 37% (Untung, 1983). Meanwhile, according Soehardjan (1976), the range was between 23% and 57%.

An assessment is required to determine the efficacy of employing natural enemies to control the population and infestation of the yellow rice stem borers. Hence, this research aims to identify the egg parasitoids of rice yellow stem borers. It also analyzes the most instrumental parasitoids in suppressing the development of the yellow rice stem borers. The findings provide valuable information on how to reduce the use of synthetic chemical pesticides, which are harmful to the environment. Ultimately, the goal is to develop an environmentally benign method of pest control.

2. Methodology

2.1 Date and Location of Research

This study was conducted from April to July 2022 at a paddy crop owned by farmers in Subak Renon, located in Renon village, South Denpasar district, Denpasar City, Bali Province, Indonesia. Subak is an organization owned by the farming community in Bali which specifically regulates the management or system of traditional rice field irrigation. Subak has irrigation areas for rice fields or moorlands (Sardiana & Wiguna, 2023). The egg parasitoids were identified at the Laboratory of Plant Pests, Faculty of Agriculture, Universitas Udayana while the progress of the parasitoids was recorded at the Laboratory of Genetic Resources.

2.2 Equipment and Materials

The instruments used in this study included a manually hand counter, a dissecting microscope, a glass tube (test tube), a 100 cm stake, a knife, a magnifying glass, paper labels, a petri dish, cotton, and gauze. Materials used were rice yellow stem borer eggs and 90% alcohol.

2.3 Implementation of Research

This research was conducted through a survey on Ciherang rice plants for nine weeks, ranging from two weeks to eleven weeks after planting, resulting in a total of ten observations. The Department of Agriculture and Horticulture of Denpasar regency provided information on the frequent attacks of rice stem borers on local farming. Subsequently, a preliminary survey was carried out in the areas impacted by the rice stem borers. The survey results were used as consideration to select the research location.

2.4 The abundance of Egg Parasitoids of Rice Stem Borers

The abundance of egg parasitoids of rice stem borers was assessed by collecting a total of 20 groups of yellow rice stem borer eggs at various heights during each observation. Each egg gathered by the group was individually placed into a glass tube and carefully monitored. After the eggs hatched, the population number and species of parasitoids were examined. The Kalshoven's identification key (1981) was used to pinpoint parasitoids under microscope. The percentage of the egg parasitoids of rice stem borers was calculated using the Nishida and Torri's formula (1970). Identification and development of parasitoids were conducted at the Laboratory of Genetic Resources, Universitas Udayana. The parasitoids were quantified as a percentage of the initial number of eggs, based on the number of larvae of rice stem borers and parasitoid hatches. Therefore, a *Tetrastichus* sp. often parasitized an average of three eggs of rice stem borers and two *Trichogramma* sp. hatched from a single egg of rice stem borers. The percentage of parasitoid can be determined using the following calculation:

$$\frac{3a}{3a+\left(\frac{1}{2}\right)b+c+d}\ x\ 100\%\ to\ calculate\ a$$

where: a: *Tetrastichus* sp.

b: *Trichogramma* sp.

c: *Telenomus* sp.

d: rice stem borer larva

The formula exemplifies a collective scenario where the eggs of rice stem borers hatch and give rise to the larvae of three species of parasitoid rice stem borers.

3. Results and Discussion

3.1 The Presence of Egg Parasitoids of Yellow Rice Stem Borers

The egg parasitoids associated with the yellow rice stem borers (YRSB) include *Tetrastichus schoenobii* Ferr (Hymenoptera: Eulophidae), *Telenomus rowani* Gahan (Hymenoptera: Scelionidae), and *Trichogramma japonicum* Ashm (Hymenoptera: Trichogrammatidae) (as shown in Figure 1, Figure 2, and Figure 3). The identical findings were also found by Wijaya (1992) in Denpasar regency. Surprisingly, after a span of 30 years, three species of egg parasitoids continue to have significance.

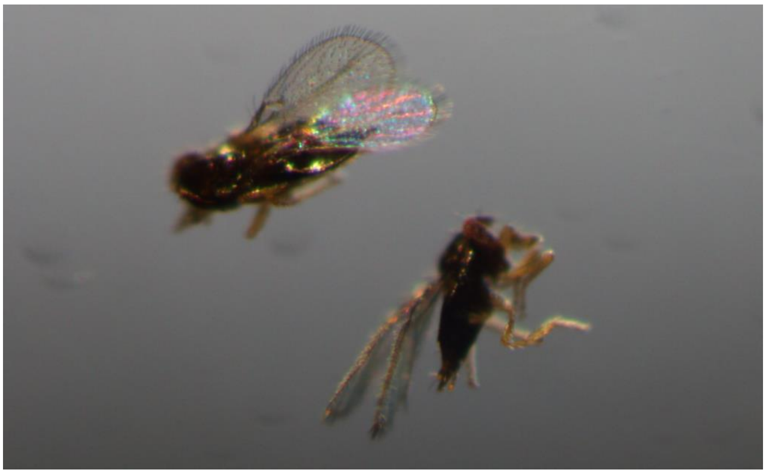

Figure 1. Egg parasitoid *Trichogramma japonicum*

The length of parasitoid *T. japonicum* is about one millimeter. The wing length is 0.8 millimeter with hair on its side. The male imago has comb-like hair at the tip of the antenna, while the female one lacks this feature (Kalshoven, 1981).

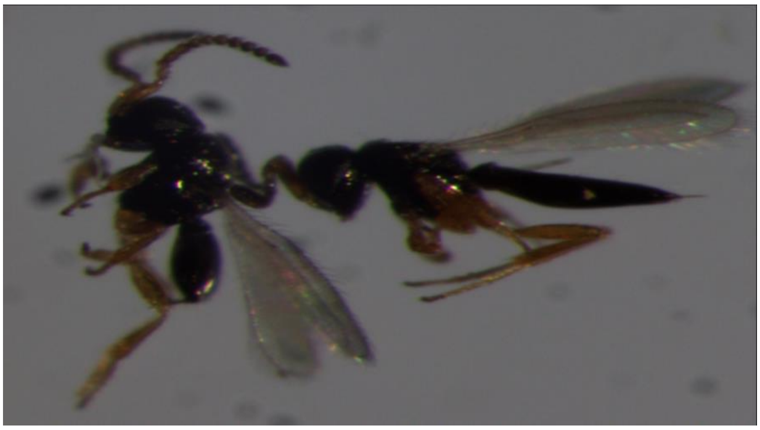

Figure 2. Egg parasitoids *Telenomus rowani*

T. rowani has a dark brown to black color and a body length of approximately 2 (two) millimeters. The flat wing measuring 0.28 millimeter is located on the thorax. The antenna has an elbow-shaped structure, with an expended tip in the female antenna and a symmetrical tip in the male counterpart (Kalshoven, 1981).

Figure 3. Egg parasitoids *Tetrastichus rowani*

The *T. schoenobii* egg parasitoid has blue, metallic green or bright green. It possesses a blunt head with smooth hair and oval-shaped eyes. The antenna is blackish brown and consists of eight segments. The lower part of the mouth has a glossy brown appearance. The cheeks exhibit a vibrant and supple appearance, while the front wings are present along with rear wings that resemble swords and have curved edges. The abdomen is shaped like a spherical cylinder and consists of eight segments. The ovipositor has a yellowish-brown color with a compact and robust structure. The legs are yellow and possess a tarsus that is divided into four segments (Kalshoven, 1981). Rauf (2000) states that the larvae of the mature *T. schoenobii* consume a minimum of three egg hosts. Thus, *T. schoenobii* requires a substantial number of eggs in order to complete its development into adults.

3.2 The role of each parasitoid Eggs in Progress Suppressing Yellow Rice Stem Borer

Three parasitoid species emerged from the egg masses of the yellow rice stem borers collected from rice nurseries in both rice fallow areas in Subak Renon, Denpasar, Bali. Included in this group are *Tetrastichus schoenobii*, *Telenomus rowani*, and *Trichogramma japonicum*. The average parasitic ability of the egg parasitoid *T. japonicum* was higher than that of other parasitoids in controlling the rice stem borers. The maximum role of parasitoid *T. japonicum* was observed in two-week-old plants, while the lowest one was recorded in nine-week-old plants. The role of *T. rowani* and *T. schoenobii* appears to increase as the plant ages (Figure 4). *T. japonicum* had a higher survival rate within a short period of 1-2 days compared to *T. rowani* (3-5 days) and *T. schoenobii* (3-9 days). Once *T. japonicum* is unable to find a host within 2 days, the parasitoid will be unable to sustain its existence (Laba, et al. 1999 in Suparta, 2001). Supartha (2001) states that the parasitoid *T. schoenobii* has a strong ability to disperse and invade new plants, allowing it to appear earlier in rice plantings compared to other parasitoids.

The concept of species diversity and dominance refers to the variety of different species present in a given area and the relative abundance of each species. The presence and behavior of egg parasitoids in agroecosystems are influenced by several farming factors, including the simplicity or complexity of the landscapes, the type and quality of the habitat, and the spatial organization, and mutual linkages within the landscape (Kruess & Tscharntke, 2000). The degree of parasitization is strongly influenced by abiotic factors such as temperature (Madbouni et al., 2017; Joodaki et al., 2018), humidity and rainfall (Schirmer et al., 2008), agricultural landscape (Jamili et al., 2015), planting patterns (Jamili & Haryanto, 2014), land typology (Wilyus et al., 2012), and altitude (Junaedi et al., 2016: Wijaya et al., 2021). Plant growth also impacts the diversity of natural predators. Yunus (2018) found that the percentage of each egg parasitoid is influenced by environmental conditions, which in turn affect the growth of the parasitoids. Environmental factors, also known as external factors, significantly influence the percentage rate of a population of parasitoid species. Pest populations exhibit dynamic fluctuations, which are influenced by the degree of environmental barriers. The vertical dimension of the location is extremely limited, related to the correlation between air temperature and altitude. As the altitude increases, the air temperature decreases, making it more challenging for insects to reach their hosts.

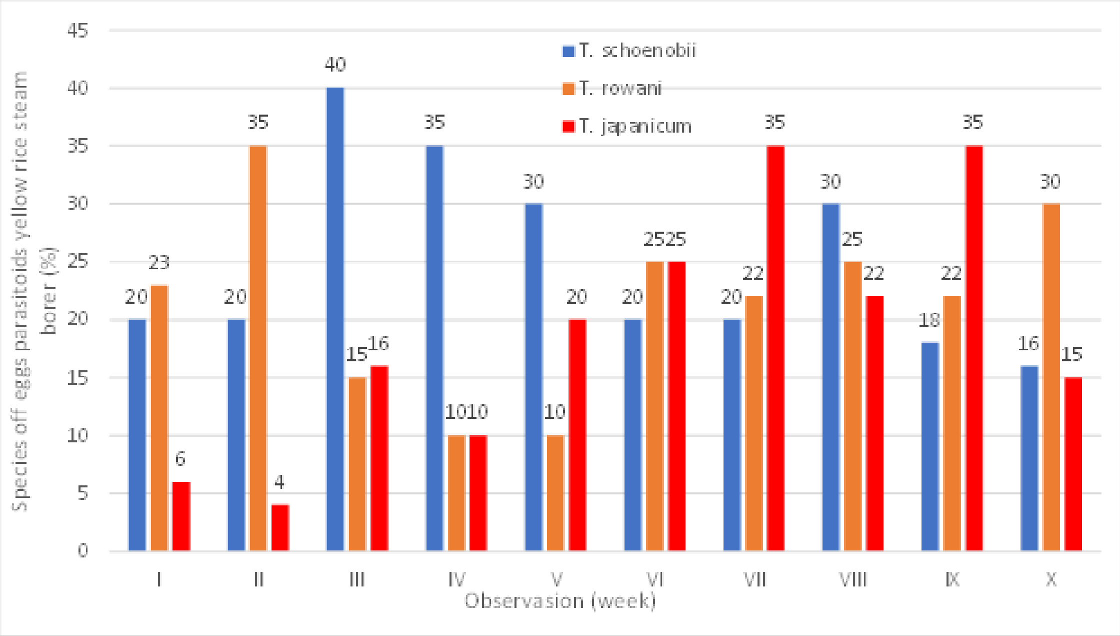

Figure 4. The role off each egg parasitoid in Rice Steam Borers

4. Conclusions

Three distinct species of egg parasitoids of rice stem borers were discovered in Subak Renon. The egg parasitoid species, especially *Trichogramma japonicum*, *Telenomus rowani*, and *Tetrastichus schoenobii*, were responsible for reducing the growth of rice stem borers. *T. japonicum* was the primary species inhibiting the population growth of the yellow rice stem borers. Egg parasitoids have a crucial role in inhibiting the growth of yellow rice stem borers, accounting for almost 66% of their control. Therefore, it is necessary to refrain from using pesticides in order to preserve their existence. If deemed required, the effectiveness of the role can be further augmented by introducing flowering plants that serve as a source of nourishment for adult parasitoids. Egg parasitoids provide a crucial role in ecologically friendly treatment. The use of biological agents presents a promising opportunity for effectively controlling pests in an environmentally sustainable manner.

Author Contributions

Contributions: Conceptualization, I. N. W. and J. Y.C.; methodology, L. B. D. C. C. and I. K. W. Y.; software, I. K. W. Y. and I. W. E. K. U.; validation, I. W. E. K.; formal analysis, I. K. W. Y. and J. Y. C.; investigation, I. W. E. K. U. and I. K. A. Y.; resources, I. N. W.; data curation, I. K. W. Y.; writing—original draft preparation, I. K. W. Y.; .I. N. W. and J. Y.C.; writing-review and editing, L. B. D. C. C.; visualization, I. K. W. Y..; supervision, I. N. W.; project administration, I. K. W. Y.; funding acquisition, I. N. W. and I. K. A. Y. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare there no conflict of interest

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